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The Status of the U.S. Precast Seismic Structural Systems (PRESSS) Program

by

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ABSTRACT

The paper provides a brief overview of the recently completed Phase I U.S. PRESSS program, and the current Phase II program, which emphasizes theoretical and experimental studies of ductile connection systems for precast frame and panel structures

KEYWORDS:

buildings; concrete; earthquake; precast; research; seismic; structures

1. INTRODUCTION

The U.S. PRESSS coordinated research program on Precast Seismic Structural Systems has now been underway for four years. The aims of the program are to develop new economically and technically viable precast systems for seismic zones, and to develop design recommendations to enable these to be used in practice.

A preliminary feasibility phase (Phase I) of research was completed last year. This phase concentrated on analytical and design studies to investigate feasible design concepts, and to provide frameworks for design recommendations and for future analytical parameter studies needed to calibrate and quantify the design recommendations.

A second phase of research, involving analytical and experimental studies was initiated prior to completion of Phase I feasibility studies.

It is anticipated that several new programs will be funded, with particular emphasis on panel structures, analytical studies and cladding/frame interaction. Applications have been submitted to the National Science Foundation for research relative to the performance of precast structures in the January 17, 1994 Northridge earthquake. As a consequence of the post-earthquake activities the scope and extent of the U.S. PRESSS program is expected to expand significantly in the near future. The following notes briefly summarize the Phase I and II programs.

2. PHASE I RESULTS

As mentioned above, Phase 1 research is complete, and the following final reports are in preparation.

2.1 PRESSS Concept Development [1]

The report summarizes analyses and design studies carried out to identify and investigate feasibility of different structural concepts for precast frame and panel structures.

2.2 PRESSS Connection Classification [2]

Different possible connection systems between precast elements are collated and reviewed for technical merit, constructability and versatility, using a standardized review format.

2.3 PRESSS Analytical Platform [3]

The report consists of a user manual for a modified version of the well known DRAIN 2D

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inelastic time-history analysis program. Three new programs have been developed. Two of these are three-dimensional programs (DRAIN-3D and DRAIN-BUILDING), one with simplified input and the ability to simply constrain floor nodes in accordance with rigid diaphragm behavior, and the other, an enhanced version of DRAIN-2D, with features and hysteretic models appropriate for precast structures.

2.4 PRESSS Design Recommendations [4]

The principal effort described in the final report on this project was an investigation of the advantages of use of reliability theory to seismic design of ductile precast concrete structures. In addition, a framework of options for seismic design recommendations, using existing and novel code formulations has been prepared [5].

3. PRESSS PHASE II PROJECTS

The following projects are currently funded in Phase II of the U.S. PRESSS effort.

3.1 Ductile Connections for Precast Concrete Frame Systems [6]

Research is being jointly carried out at the University of Minnesota and the University of Texas at Austin, to provide rational design recommendations for seismic design of precast frame systems using ductile connections, based on experimented testing of a number of options representing the four categories of connectors being considered in the PRESSS Phase II research program. The categories are:

1. Nonlinear elastic connections
2. Connections relying on axial tension and compression yield of connecting elements
3. Connections involving shear yield
4. Connections involving added damping.

To date, tests have been carried out on the first two categories.

3.2 Ductile Connections for Precast Concrete Panel Systems [7]

Parallel to the above mentioned frame program, a study being jointly carried out at the National Institute of Standards and Technology (NIST), and the University of Nebraska-Lincoln is investigating ductile connections for panel structures, and seismic systems for low-to medium-rise buildings in regions of moderate seismicity.

Current testing is focusing on vertical connections between panel units, where the connectors are designed to be weaker than the panels, and to exhibit some energy dissipating characteristics.

3.3 Precast Frames with Unbonded Tendons [8]

At the University of California, San Diego, the use of continuous prestressing with unbonded tendons is being investigated. The focus of the research is to structurally simplify the precast elements as much as possible, and to minimize the amount of mild steel reinforcement. Particular emphasis is being placed on the force transfer mechanism within the beam-column joint region. Preliminary testing has been carried out on one exterior and one interior beam/column units, and six more are planned. Results indicate much lower levels of damage for a given drift level than for equivalent monolithic joints of similar dimensions and strength.

3.4 High Performance Fiber-Reinforced-Concrete (FRC) Energy Absorbing Joints for Precast Concrete Frames [9]

Building on previous research at the University of Michigan, Ann Arbor, experimental research is being carried out to provide design criteria for FRC plastic hinge regions forming the connections between precast elements. The specific objectives are (i) to determine the bond-stress/slip relationship between FRC and rebar in the plastic hinge region, (ii) to determine the shear strength of FRC under monolithic and cyclic shear loading, and (iii) to develop a model for the joint to describe its hysteretic moment-rotation response.

3.5 Seismic Response Evaluation of Precast Structural Systems for Various Seismic Zones and Site Characteristics [9]

This analytical project is being carried out at Lehigh University. The aims are to carry out dynamic inelastic analyses of specific precast frame and panel buildings with connection characteristics appropriate for the four basic connection categories described earlier. Based on the results of these analyses, appropriate simplified design rules will be generated. Of particular importance is the quantification of dynamic amplification effects for shear and moment in columns, beams, and panels, so that required strength of precast elements can be determined based on appropriate capacity design principles.

3.6 Development of Seismic Design Recommendations for PRESSS

The continued refinement of design recommendation, begun in Phase 1 of the U.S. PRESSS project, is being continued in Phase II. This will be a joint effort with input from the University of Illinois, the University of California, Los Angeles, and the University of California, San Diego. Current efforts are well advanced to provide prescriptive requirements for 'strong-connection' precast frames [9].

3.7 Dynamic Scale Model Tests

A program of small scale dynamic shake table model testing of precast frames using different connector types is currently being planned at the University of Illinois, Champaign, Urbana. These tests will enable comparisons to be made between predicted results from time history analyses, and experimental results on complete structural systems.

4. CONCLUSIONS

The above represents a very brief summary of the U.S. PRESSS program. It is expected that further projects will be added to the program in the near future. A final stage (Phase III) is currently planned involving full-scale subassemblage testing of one or more five-story precast structures to test the final design concepts and analytical models developed in the program. These will be accompanied by rigorous analytical studies, and comparison of theoretical predictions and experimental results.

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